Energy and
Environmental
Research Corporation

July 20, 1990

INTERMOUNTAIN POWER SERVICE CORP.
Brush Wellman Road
Route 1 Box 864
Delta, Utah 84624

Attn: Mr. Jim Nelson

Ref: Burner Inspection Report

Dear Jim:

Enclosed is the second draft copy of the Burner Evaluation. Appendix B "Photographs" should be saved as you will need to insert them in one of your three final reports.

Please notify me if you have any comments or agree with the report as is.

Sincerely yours,

Todd Melick

Todd Melick
Sr. Design Engineer

jimnel.02:db

* Schedule for return 10/8/90

Unit 1 retest?

recommend letter form change order

Comb Balancing Info.
Register Settings
typical O_2 profile
3D

ex) ~~[illegible]~~ Maint Schedule
photos + headings

→ purch orders
change order

Coal Burner Condition and Estimated Remaining Life Evaluation - ~~IPP Units #1 & 2~~

IGS

Do we want to state Units 1+2 - in the title of this report?

- they only inspected, thus technically evaluated just Unit 1

alternative Intermountain Generating Station

Final Report

DRAFT

Prepared by:

Todd A. Melick

Todd M. Sommer

Energy & Environmental Research Corporation

Engineering Services Group

Orrville, Ohio

Prepared for:

Intermountain Power ~~Services~~ Corporation

Delta, Utah

Bound.

July 20, 1990

IP7_004347

TABLE OF CONTENTS

IP7_004348

1.0 INTRODUCTION

The purpose of this evaluation is to provide technical support to Intermountain Power Service Corporation (IPSC) in evaluating the existing condition and estimated remaining life of the burners at the~~ir~~ Intermountain Generating Station ~~Power Plant~~. Energy and Environmental Research Corporation was requested to perform this evaluation so that an expert unbiased opinion could be established to be used for ~~before~~ negotiations between the Intermountain Power Project ~~IPSC~~ and the OEM (spell out) ~~continue~~.

The burners have had numerous modifications, adjustments, and repairs made, in addition, to changes in operating parameters since their initial service. IPSC is concerned that the structural integrity and remaining life of the burners has been significantly effected. A burner inspection was performed on IGS Unit 1 and the results and recommendations of that inspection are included in this report.

Add

This should be a footnote on bottom of page 6

Throughout this report, references will be made to photograph numbers, for example, (Photo #1). All photographs referenced are attached in Appendix B, "PHOTOGRAPHS", at the end of this report.

2.0 BACKGROUND INFORMATION

This main section provides a description of Intermountain Generating Station Unit~~s~~ 1 and ~~&~~ 2 steam generators. It also provides necessary background information concerning the start-up and operation of these Units.

2.1 IGS Unit Information

Intermountain Generating Station (IGS) Units 1 and ~~&~~ 2 are indoor, balanced draft, parallel back-end, Carolina Type Radiant Boilers provided by the Babcock & Wilcox Company. Each unit fires pulverized coal from a combination of the forty-eight high input dual-register burners arranged in four rows of six burners on both the front and rear furnace walls. The burner windboxes are compartmented with air dampers located on each end. Furnace dimensions are 85 feet wide, 60 feet deep, and 299.5 feet from the lower wall header centerline to the drum centerline. Figure 1 illustrates the general boiler arrangement of the units.

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Add * Additionally, [illegible] (including a "Do nothing" [illegible]) [illegible] construction [illegible] [illegible] performance criteria are included in this evaluation.

Th[illegible]mbers, for example, [illegible]ppendix B, "PHOTOGR[illegible]

This should be a "footnote" on bottom of page 6

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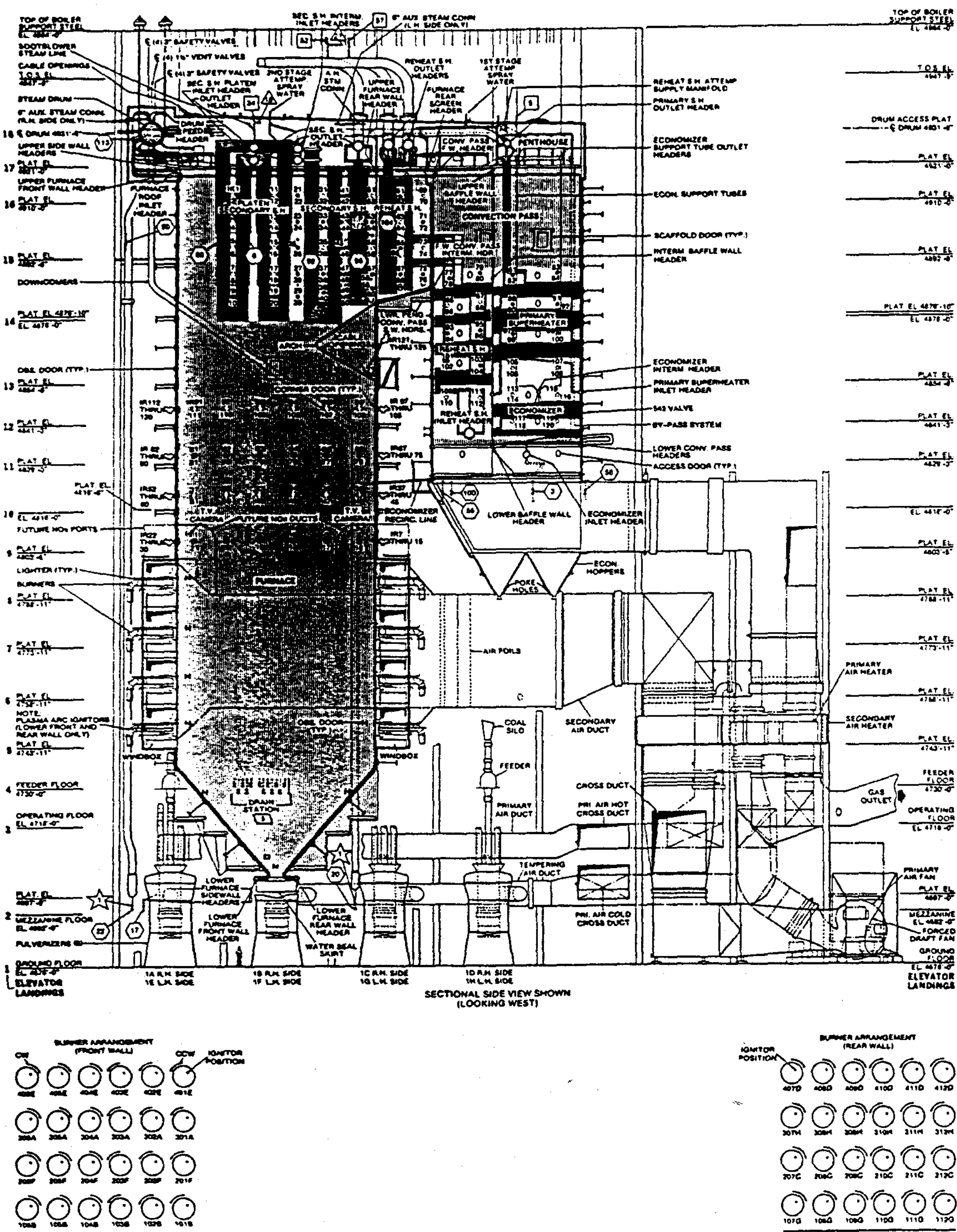
IP7_004351



INTERMOUNTAIN POWER PROJECT
UNIT NO. 1
LYNNDYL, UTAH

CAPACITY LB STEAM PER HOUR .... 6,480,000 SUPERHEATER OUTLET TEMPERATURE, F 1005
SUPERHEATER OUTLET PRESS., PSI.......... 2976 REHEATER OUTLET TEMPERATURE, F 1005

BLACK & VEATCH ENGINEERS

BABCOCK & WILCOX RADIANT REHEAT BOILER

Figure 1

The maximum continuous rating of each steam generator is 6,600,000 lb/hr of main steam at 2640 psig and 1005°F at the superheater outlet with reheat steam flow of 5,285,000 lb/hr at 551 psig and 1005°F with a feedwater temperature of 555°F. The "maximum capacity" load (100% - guaranteed load) for each unit is 6,100,000 lb/hr of main steam at 2510 psig and 1005°F at the superheater outlet with a reheat steam flow of 4,925,000 lb/hr at 521 psig and 1005°F with a feedwater temperature of 545°F. Main and reheat steam temperatures are controlled to 1005°F from MCR down to 65% load (3,925,000 lb/hr) by a combination of gas biasing, spray attemperation, sootblowing, and excess air. The design pressures of the boiler, superheater, economizer, and reheater are 2975, 2975, 3050, and 750 psig respectively.

The units are designed for cycling service and each have ~~has~~ been constructed with a partial boiler steam by-pass system. The units can be operated in either a constant pressure, variable pressure, or hybrid pressure mode of operation. These units have typically been base-loaded units with 96-98% load capacity since commercialization, but the units should still be capable of cycling service. The burners should remain fully adjustable throughout the load range.

2.2 IGS Burner History

Unit 1 went into commercial service on May 10, 1986 and Unit 2 on July 1, 1987. Cooling air requirements for out of service burners were based upon final ~~was initially set during~~ performance testing for boiler acceptance. During the first outage after start-up, physical damage to the burners became ~~was~~ apparent. Since then the burner metal temperatures have been monitored closely, but the cooling air is still limited in order to meet boiler efficiency main steam and reheat steam temperature guarantees.

Approximately one year after commercial service began, each unit received new Heavy Duty Air Registers on each upper level of burners due to complications ~~the condition~~ of the original registers. The original 70" dual register burner is illustrated in Figure 2. The burner is considered "high input" by B & W because the heat input and physical size has exceeded all previous dual register burners manufactured by them. The H.D. type register replacement corrects some of the problems experienced with the original burner. The door shaft diameter has been increased from 1/2" to 3/4". The door shafts are fixed in place and the door

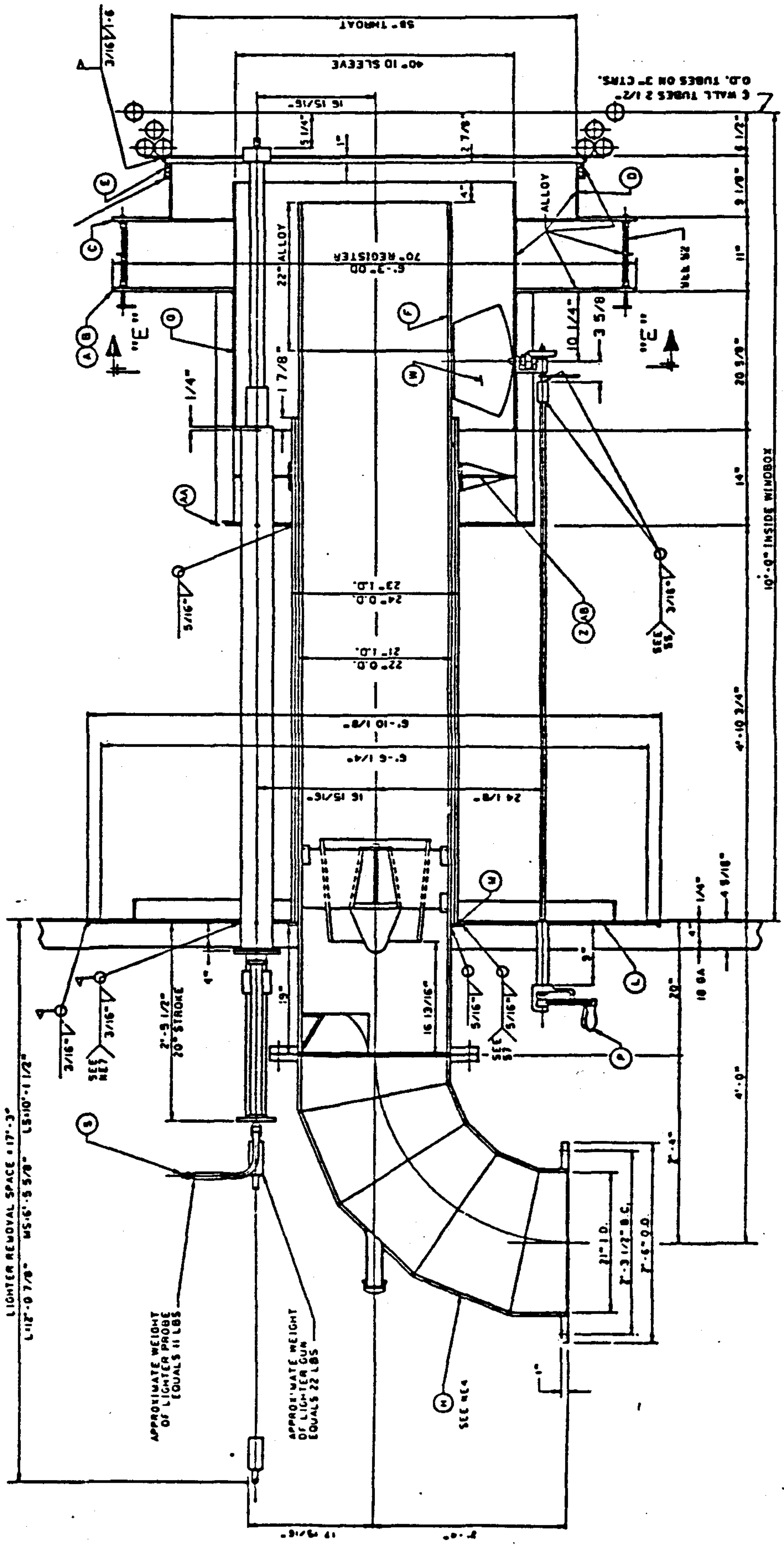


Figure 2

rotates on the shaft. The linkage has been moved from behind the rear plate to the center of the register, and is not affected by the expansion of the rear plate. These changes have simplified the burner and have improved its operation.

2.3 Typical Utility Burners

A utility burner normally will operate for 20-30 years without major component replacement. Most boilers have their own unique operating conditions, so some burners receive more severe duty than others. This is the reason for the 10 year margin. Wear items such as coal nozzles, diffusers, deflectors, and coal elbows will need replacing. The rope packing is also a high maintenance item as it has a tendency to disintegrate every couple of years due to heat and the grinding action caused by thermal expansion. Failure of registers, throat casings, slip seal casings, or extensive weld breakage in the first few years of operation is not typical.

There are none (T/C's etc) originally supplied and is part of the problem.

No T/C's, no flow measurement / No ΔP / register position (damper position + WB press is available) originally provided by the OEM

The instrumentation and controls on these burners is typical for a B&W dual register burner and is usually sufficient?. However, the increased size of this burner (located in a compartmented windbox) has created problems that were not originally thought possible. A flow balancing device such as a pitot tube would be beneficial on these large burners, but was not previously necessary on 54" diameter dual register burners that were located in a compartmented windbox with full load windbox pressure of 4 inches water.

Providing the correct amount of cooling air to out of service burners is also not normally a problem. Sufficient cooling air is usually available as needed to keep the burners cool without impacting boiler performance. These large burners however, are requiring more cooling air than was originally anticipated.

To prevent an overheating condition on the burners, the Intermountain Power Project installed air thermocouples on every other burner ~~[illegible]~~ to have continuous monitoring capabilities. ~~[illegible]~~ Operating temperatures providing by the boiler manufacturer for the out of service burners are 1350°F.

3.0

T ... during the

March 27 ~~3-27-90~~ ... servations,

recomme ... only. No

destruc ... re utilized

as they ... IPSC. IPSC

IP7_004355

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consider: - WB air flow measurement

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3.0 BURNER INSPECTION

This section summarizes the visual observations that were made during the ~~3-27-90~~ March 27 1990 outage on Unit 1. It should be noted that all observations, recommendations, and conclusions are based on visual information only. No destructive or non-destructive inspection or analysis techniques were utilized as they were considered beyond the scope of inspection requested by IPSC. IPSC

IP7_004356

employees James H. Nelson, P.E., Supervising Engineer - Operations Support, Aaron Nissen, P.E., Supervising Engineer - Results, and control room operators were also interviewed to gather information concerning operating history and practices.

3.1 Physical Observations

All forty-eight burners on Unit 1 were inspected on March 27, 1990 by EER employees Todd Melick, Sr. Design Engineer and Sig Sundberg, Sr. Field Engineer. The burners were inspected from inside the windbox. A burner inspection sheet was completed for each burner to note the condition of each major component. Conditions such as warpage, exfoliation, overheating, weld breakage, and general operability were noted for each burner. See Appendix A for the individual burner inspection sheets. The following problems were apparent:

1. The welds were found broken ~~on~~ on support the bar that connects the outer air register front and back plate together. This was found on four different burners ~~on four burners.~~ Burner C4 (Photos #24 & 25) had six of these bars broken and the back plate had subsequently warped at least 6" inches. This item is of particular concern and is considered a safety related issue.

2. The register handle and quadrant were bolted together to prevent any adjustment, so register doors could not be stroked to determine freedom of movement. The register doors were stroked a small amount (play in linkage) from the windbox. It was noted that three burners had register linkage that was locked tightly and would not move at all.

3. The register rear plate was warped (varied from 1/2" to 1") on twenty-six burners (Photos #22 & 23).

4. The register front plate was warped (Photos #18-21) on fourteen burners.

5. The burner register or the throat sleeve was misaligned with the bent tube opening of the waterwall (Photos #15-17) on eleven burners due to warpage.

6. The weld that connects the pull handle to the inner air zone disk was completely broken on one burner (Photo #28). Another inner air zone disk was cocked at an angle from vertical and was being held there by the pull handle.

7. The reinforcing bars that are welded to the outside of the inner air sleeve (Photos #26 & 27) showed signs of overheating on twenty burners. Large flakes of metal broke away from the burner with only fingertip contact. This was not caused by cutting or field alterations since it was not found on all burners. The maximum recommended working temperature of this material had undoubtedly been exceeded. Also, one burner had broken welds where the reinforcing bar attached to the inner air sleeve.

8. The support channel connecting the register front plate to the register support bracket was bent (Photo #7) and unable to slide freely on ten burners. This was caused by insufficient clearance between the retainer and register support bracket. The bending of the support channel distributes additional stresses to the register front plate which enhances the warpage of that plate.

9. The throat sleeve and the throat sleeve casing on all forty-eight burners needed repair or replacement. B & W Construction was making these repairs during the burner inspections. The rope seal packing was virtually non-existent. This was allowing large quantities of air to escape into the furnace without flowing through the burner. Also, approximately 90% of the welds connecting the throat sleeve casing to the furnace wall (Photos #8 - 10) were broken. The casing was free to move in any direction and this caused large gaps (1-2 inches) for air leakage into the furnace. A conservative 1" gap around the burner would amount to 6.9% of the throat area.

Throat area is $(\pi)58^2 / 4 = 2642$ sq in

Air gap is $(\pi)(58)(1) = 182.2$ sq in

Percent leakage is $182.2 / 2642 = 6.9\%$

10. A general observation th~~at was~~ noted on each burner level was that the middle burners had definitely experienced higher out of service temperatures (due to insufficient cooling air flow) than the outside burners. This is in contrast with in service burner operation where the ~~one~~ problems is of getting enough air flow to the outer burners.

3.2 Summary of Inspection Information

The general condition of the burners at this time is considered very poor. Numerous attempts to correct the problems have left the burners looking severely mistreated. All the register doors have been cut (Photos #1 & 2) to allow door movement ~~when the~~ due to register plates overheat and become severely warped. A triangular section has been removed along each door side that varies from one to two inches in width, and from the door tip to almost the door shaft in length. The original clearance before modification was 5/16" from the register door edge to the register plate with a tolerance of plus 0" and minus 1/32". The register doors still have curved edges as a result of warpage before the door edges were trimmed. It appears that about 15% of the register door has been removed. Many register door shafts (Photo #3) are also bent and rotation appears difficult. The result of these modifications is a register with decreased ability to generate swirl, and a register that would have severe leakage in the closed position.

The outer air register assemblies have all been cut free from the inner air sleeve (Photo #4) so that the whole registers can move independently from the rest of the burner. The throat sleeve has also been cut free from the register front plate. Metal clips were installed in an attempt (Photos #5 & 6) to restrict the amount of movement between the throat sleeve and register front plate. The register is presently supported in only three locations. One is at the top of the inner sleeve, and the other two are supports from the register front plate (Photo #7) to the register support bracket. This support system promotes individual movement of the register plates which results in weld failures.

for Unit 1 Spring Outage Inspection

Burner component failures and the number of occurrences is summarized below:

Description of Failure	Occurrences
Welds broken on register connecting bars	4
Register linkage unmovable	3
Register rear plate warped	26
Register front plate warped	14
Burner misaligned with bent tube opening	11
Weld broken on pull handle to sliding disk	1
Sliding disk severely cocked	1
Inner air sleeve reinforcing bars overheated	20
Support channel bent and bound	10
Throat sleeve and throat sleeve casing ~~damage~~ warpage	48

3.3 Conclusion of Burner Conditions based upon Inspections

The burner inspection revealed that the burners have received a combination of high temperatures and stresses. The excessive temperatures have severely warped the stainless steel components and exfoliation of the carbon steel exists on 20 different burners. The burners are also improperly supported which assists the high temperatures in permanently warping the burners. In an attempt to fix these problems the burners have received detrimental field work that has created additional stresses.

4.0 BURNER EVALUATION

4.1 Existing Burner Design

The size of the 70" inch register greatly exceeds any other previous burner register sold by B & W. The diameter of this register was increased from the previous standard size while all plate thicknesses, material specifications, and manufacturing processes remained the same. This has created two problems. The burner temperatures are higher than expected even using the "normal" amount of cooling air, which can be attributed to increased radiant heat transfer through the larger throat area. The other problem is that higher combined (thermal, residual, bending, etc.) stresses are greater. The combination of higher stress and temperatures have produced the higher than expected rate of deterioration.

4.2 Metal Temperature Limitations

The majority of the stainless steel material on this burner is AISI 304. Although the maximum operating temperature (with regard to oxidation resistance) of this particular stainless steel is several hundred degrees higher, the creep strength is greatly reduced at elevated temperatures. Creep strength is the ability to resist permanent strain that increases as a function of time under stress. Depending on the source, the creep strength of AISI 304 stainless steel is approximately 9.5 (4.5) KSI at 1350°F. Figure 3 illustrates the creep strength vs. temperature relationship for 304 stainless steel. For a long term installation such as this burner the 304 stainless material should be limited to 1150°F. which has 9.5KSI creep strength. contention w/ B&W

* Creep Strength vs Boiler Life Curve

Carbon steel for a long term installation such as a burner should be limited to 850°F. verify The thermocouple on the coal nozzle is located at the junction of the stainless and carbon steels. This thermocouple should be set to alarm at 850°F. The reinforcing bars that are welded on the outside of the inner air sleeve has definitely exceeded its allowable temperature. Large flakes of material can be picked off of the bars and the material that is left is porous and brittle.

this now becomes controlling factor (typical ΔT=200°F which sets SS temp at 1050°F)

What's recommended material changeout? 309

How much/far back

4.3 Cooling Air Requirements and Monitoring

Temperature variation around the burner was observed during the inspection. A thermocouple on one side of the burner may not be alarmed to indicate excessive temperatures, but if the thermocouple was placed in a different radial position around the burner, the recommended temperature would be exceeded. These thermal gradients produce high thermal stresses that cause the severe warpage.

Correct monitoring of the cooling air to each burner is the optimum way to reduce these temperature variations. Because cooling air flow is limited it becomes that much more important to effectively use what is available.

strain

Creep Strength vs. Temp. for AISI 304 SST

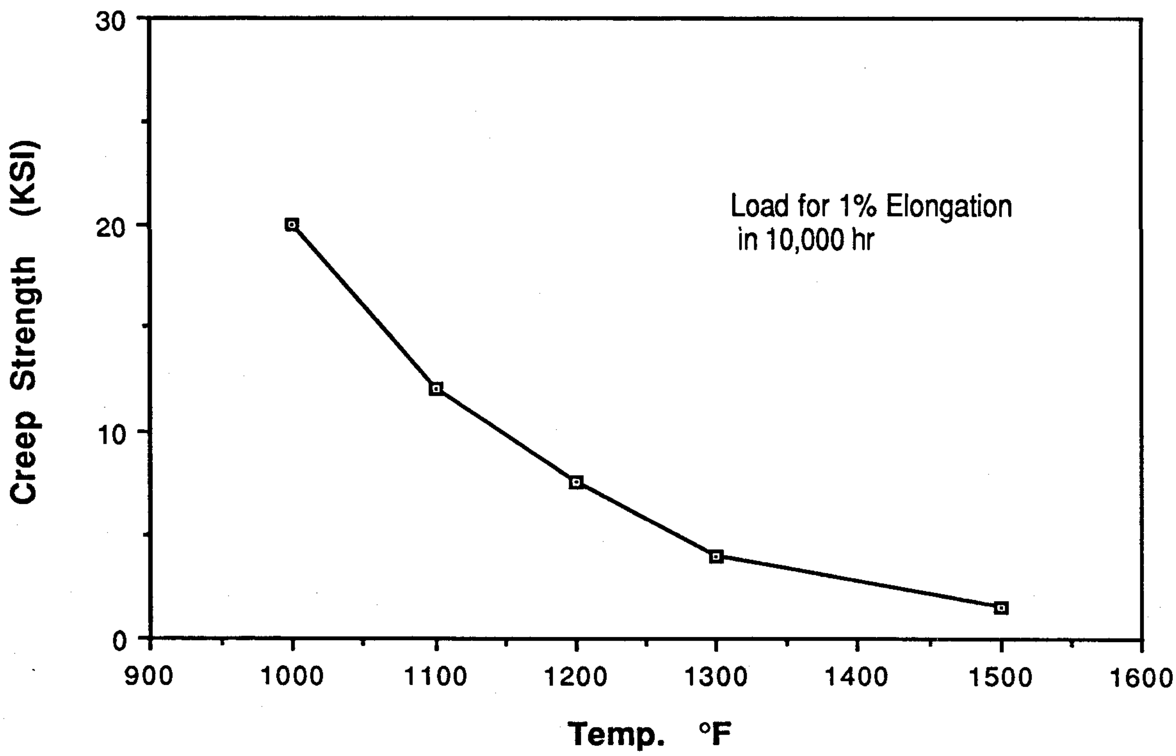
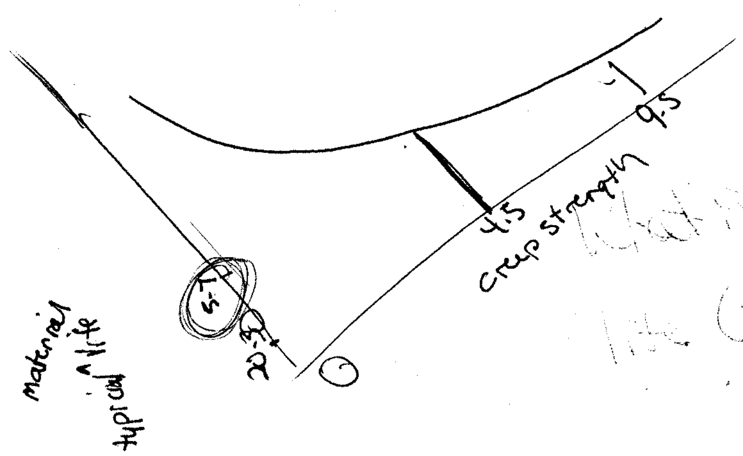


Figure 3



What is the creep strength to life (years) relationship?

f(loading)

IP7_004362

Individual windbox secondary air flow measurement would be beneficial only ~~if~~ after it is determined that the flow is balanced ~~to~~ cooling each burner.

The burners registers and sliding disk are currently adjusted for ~~full load~~ on-line operation. When the burners are taken out of service no adjustments to burner registers are made. The windbox pressure for in service burners is approximately 1.0 inch of water, and out of service windbox pressure is -.7 inch of water. Under these conditions it is difficult to imagine that the cooling air is being distributed equally. The pressure drop across the burner is too small (without register adjustment) to assure equal air distribution.

It was observed during the burner inspection that the burners located in the center of the windbox have experienced much higher temperatures than the outside burners. This has occurred when the burners are out of service and was caused by insufficient cooling air to the center burners. This can be seen on Figure 4. This is a printout for the thermocouples that are located on Unit 1. Row H is out of service and burner number 3 is experiencing higher temperatures than the outer burners, which is generally the case. Also note that the secondary air damper is at 30% and not the usual 10%. The coal nozzle temperature is higher is 70-100°F ~~higher~~, and the register plate surface is 100-140°F ~~higher~~. These differentials will increase as the cooling air is reduced. It can also be noticed that the coal nozzle is approximately 280°F cooler when the burner is in service and the register plate is 200°F cooler. The temperatures on the throat seal fluctuate 300°F or more due to the large gaps in the slip seal casing. The thermocouple is evidently located near a large gap when a temperature of 600-800°F is reported. The air leakage through the large gaps in the slip seal casing only compounds the limited air flow problem. The air bypasses the burner and thus provides no cooling to the burner components. The air gap on the slip seal casing must be maintained at a minimum.

Curve (ΔP correlations)

Pitot tubes located in the burner air stream would accomplish balanced cooling air to each burner, but it would be a difficult application on this burner. The next best method would be to perform cold air tests with cooling air flow in order to balance the flow to each burner. A register setting would need to be determined for each burner for out of service operation.

complete traverses inlets + ~~outlets~~ outlets

Please provide an Appendix on how to perform cold air testing to balance air flows to each individual burner (for out of service operation). Plus explain how to utilize these setting in an in-service condition where settings are made based upon combustion tuning through the load range. Modality of registers from one condition to the other is questionable

IP7_004363

I65

IPP UNIT #1

Unit Load 840 MW

	East		West
D	(2) 590.F 1014.F 972.F 877.F	(4) 569.F 1066.F 956.F 665.F	(6) 580.F 935.F 933.F 650.F
H	(1) 819.F 1110.F 985.F 1018.F	(3) 913.F 1223.F 1130.F 794.F	(5) 845.F 1083.F 1081.F 661.F
C	(2) 622.F 898.F 948.F 861.F	(4) 579.F 978.F 932.F 646.F	(6) 609.F 636.F 1052.F 953.F
G	(1) 562.F 969.F 916.F 966.F	(3) 551.F 1012.F 989.F 667.F	(5) 598.F 946.F 967.F 648.F

West		East	
(6) 581.F 994.F 835.F 715.F	(4) 474.F 894.F 1053.F 760.F	(2) 560.F 797.F 938.F 717.F	E
(5) 611.F 647.F 1027.F 964.F	(3) 546.F 1102.F 1132.F 879.F	(1) 589.F 1006.F 1064.F 654.F	A
(6) 602.F 956.F 1018.F 924.F	(4) 610.F 1052.F 1019.F 649.F	(2) 560.F 1042.F 1006.F 761.F	F
(5) 574.F 1006.F 960.F 1003.F	(3) 599.F 1007.F 1054.F 896.F	(1) 575.F 1064.F 1075.F 982.F	B

1. H Pulverizer O.O.S. with secondary air dampers at 30%.
2. All in service pulverizer feeders at 47 T.P.H.
3. All secondary air dampers on in service pulverizers at 65% position.

Notes: a. Burner number in parenthesis

b. Description of burne temperature reading:

#1 Coal Pipe
#2 Outer Register
#3 Outer Register
#4 Throat Seal

Figure 4

3 4 5

4.4 Burner Line Fires

Several burners have experienced fires back in the coal nozzle that has destroyed the nozzle tips. Coal particles are probably settling out in the coal pipe to cause these fires. The coal nozzle velocity is in line according to the Pulverizer-Burner Coordination Curves. The concern is whether or not these velocities are maintained throughout the coal pipe. If test connections are located correctly and tests prove that these velocities are correct to each burner, then the velocity should be increased in small amounts to determine if this will eliminate the fires.

4.5 Register Controllability

what ratios

The registers and sliding disk should be adjustable under all conditions. The burner should adjust so that a turndown ratio of ~~2:1~~ 4:1 can be accomplished. The burner should also be capable of being closed completely so that a large enough pressure drop can be created to equally distribute the cooling air. Considering the amount of trimming that has taken place on the register doors, it is questionable whether or not enough pressure drop can be created to accomplish this. Other ways of closing the register openings such as shrouds could be utilized.

The physical appearance of the registers would indicate that adjustment while in service would be impossible for approximately 50% of the burners. The severity of the warped register plates and the bent door shafts create binding that prevents any adjustment. Register adjustment during the inspection was not allowed due to the fear that the register doors would not return to their original position. Only two sliding disks appeared to be impossible to operate. The remainder of the disks were free from any binding and appeared to be in good shape.

Estimate Cost?

variable control → spin vane (need new gear design) → back plate → outer register (only w/ HD design) w/ slip joint

48 controllers

4.6 Estimated Burner Life

Considering the current burner condition and the amount of deterioration that has taken place in less than five years, the estimated remaining burner life is expected to be less than five years. It is expected that the majority

IP7_004365

of the burners will have major failures like burner C4 (Photos #24 & 25) if the burners continue to operate at the present temperatures and conditions. It is estimated that $30,000 per outage will be required for labor and materials to rebuild the burners to maintain operating conditions. The burner failures will consist mainly of register and throat destruction.

5.0 B&W'S REPAIRS TO BURNERS

5.1 Recent Repairs

B&W Service and Construction was on site during the one week outage when the burners were inspected. They were replacing the slip seal casing on all 48 burners on Unit 1. These casings have been repaired or replaced on previous outages. A number of little gusset plates (4-8) were being welded on the outside of the casing in an attempt to hold the casing in place. The previous casing was welded directly to the tube wall. The casing would try to grow from thermal expansion (1/2-5/8" on the diameter) but was limited until it could break the welds. During this time the free end of the casing would expand and the casing would resemble a 45° cone. The packing would fall out and large gaps (1-2") would appear. This new installation is at best a short term replacement, because the problem of thermal expansion is not being taken care of properly. By restricting the movement, either large stresses will result or these large stresses will cause the welds to break again.

The alloy section of the coal nozzle was oval on a few burners and was replaced. This was probably caused by burner line fires.

5.2 Previous Repair History

In the first few years of service, many repairs were necessary on the original burners. These repairs were required due to original manufacturing deficiencies and installation errors. Since then, failures have been the result of excessive temperatures and stresses. Numerous alterations have been made in an attempt to keep the burners operating. Below is a listing of the most significant these alterations.

Unit	Date	Description of Repair
1	11-86	Register plates were warped and a reinforcing band was attached to the rear plate. Numerous welds were broken and repaired.
1	5-87	Welds joining the air sleeve to the rear plate had failed. These welds were all cut free to allow differential expansion. Reinforcing bars on air sleeve were overheated. Two middle burners on each level had more severe warping due to the air disk being throttled. Thermocouples were installed by IPSC to monitor burner temperatures.
1	11-87	New HD registers were installed on front and rear walls of burner level four. The 22" alloy tip on all 48 coal nozzles was replaced with a 33" section. Retaining lugs and clips replaced the previous weld attachments on the throat and inner air sleeves.
1	3-88	The register vanes were trimmed on all registers. Lighter shrouds were re-attached.
1	1-89	Heavy duty auxiliary outer register drive arm handles were removed as they were not providing enhanced outer register mobility.
2	11-87	The 22" alloy tip on all 48 nozzles was replaced with a 33" section. Retaining lugs and clips replaced the previous weld attachments on the throat and inner air sleeves. The register doors were trimmed on all burners.
2	4-88	Lighter shrouds were re-attached.

2 ✓ 9-88 Slip joint modification was made on all register drive rods to allow thermal expansion to occur. The welds joining the inner air sleeve to the rear plate was cut free to allow for thermal expansion on the lower 36 burners.

6.0 ALTERNATIVES

This section itemizes four different alternatives for future burner operation. Estimated burner life and a cost summary is included for each section. New registers for all of the alternatives should be installed as a one piece design to avoid the problems that were experienced with HD registers. and to return the burners to an undamaged, like-new condition.

6.1 Continue Current Mode of Operation

Alternative 1

If the out of service burners continue to operate at 1350°F the HD registers, throat sleeves and throat sleeve casings will need replacing every 5-7 years. Burner maintenance will also be required at each outage to repair broken welds and straighten warped burner components. It is estimated that labor and materials for each (common) outage will be (Breakdown?) $30,000. The registers will remain adjustable for only a short period of time and balancing of cooling air to each burner will be difficult. Performance of the Unit will remain the same. Burner replacement would require approximately a six week outage depending on the size of the crew. Hopefully the work could be done during a scheduled outage and not require forced outages. The following cost summary is based on a quantity of 48 burners for one unit.

like-new condition

CYCLING?

Cost Summary

Material Cost (does not include OEM markup)	$292,800
Engineering	20,000
Freight	12,000
Installation Labor & Equipment	432,000
OEM markup (20%)	
Total (every 5-7 years)	$756,800

6,800 as Blk

+30K $ MNTNCE/OUTAGE

per year

$150K total

NEED PRESENT VALUE OVER LIFE

Add: variable control registers I&C ΔP

Alternative #3

Will include SS nozzle modification

IP7_004368

philosophy

4wks / once per year

6.2 Change Mode of Operation

Overall boiler performance should improve slightly. Eight pulverizer operation would eliminate the need for cooling air, reducing excess air requirements, thus lowering stack gas losses. Additionally, fineness would improve since feeder speeds would lower nine percent which should offset the auxiliary power requirements of the additional pulverizer

~~###~~ Incorporate Alter 6.3 measures (incl cooling air) if 8th pulv not available.

te … is … wo … al … ye … av … ca … tak … 48 … ith satisfactory … l nozzle average … ondition, (this … ve casings) and … would be 20-30 … atures could be … full load could … then have to be … n a quantity of

pulverizer overhauls which would … pulverizer work be conducted during maintenance outages.

I DONT THINK WE CAN CONSIDER THIS OPTION

Material Cost (does not include OEM markup)	$292,800
Engineering	20,000
Freight	12,000
Installation Labor and Equipment	432,000
Increased Auxiliary Power	?
Pulverizer Maintenance	?
Total (20-30 year life)	$756,800

Alter 3 6.3 Increase Cooling Air Requirements

The burners should be rebuilt to like new condition (this would require new HD registers, throat sleeves, and throat sleeve casings) along with the following modifications so they can operate for 20-30 years at 1150°F. The coal nozzle thermocouple should be limited to 850°F.?

1. The outer register should have additional supports. Allowing the register assembly freedom to move independent of the inner air sleeve is desirable, but the register rear plate should also be supported off of the register support bracket as is the front plate. Round edges and adequate clearances should also be incorporated into the register support bracket retainer to assure that the register assembly can expand as needed.

Please provide drawing of the proposed mods just HD's

IP7_004369

Eight Pulverizer

6.2 ~~Change Mode~~ of Operation

The burners that are in service currently operate with satisfactory temperatures. The registers average about 1000°F and the coal nozzle average is approximately 580°F. If the registers were in "like-new" condition, (this would require new HD registers, throat sleeves, and throat sleeve casings) and all 48 burners would ~~remain~~ be placed in service, the estimated burner life would be 20-30 years. Burner maintenance would be minimal ~~if~~ since the high temperatures could be avoided. Overall boiler performance should increase slightly. Eight pulverizer operation would eliminate —— However, operating the pulverizer mills at less than full load could cause vibration. Increased pulverizer maintenance work would then have to be taken into consideration. This alternative has major impact on regular on-line pulverizer overhauls which would force pulverizer work be conducted during maintenance outages. The following cost summary is based on a quantity of 48 burners for one unit.

Cost Summary

Material Cost (does not include OEM markup)	$292,800
Engineering	20,000
Freight	12,000
Installation Labor and Equipment	432,000
Increased Auxiliary Power	?
Pulverizer Maintenance	?
Total (20-30 year life)	$756,800

I DONT THINK WE CAN CONSIDER THIS OPTION

6.3 Increase Cooling Air Requirements

The burners should be rebuilt to like new condition (this would require new HD registers, throat sleeves, and throat sleeve casings) along with the following modifications so they can operate for 20-30 years at 1150°F. The coal nozzle thermocouple should be limited to 850°F. ?

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② Please provide drawing of the proposed mods

Variable control

Inc add AP

IP7_004370

2. The throat sleeve casings should be redesigned to allow for the large thermal expansion. This will eliminate the extreme warpage and weld breakage.

please provide drawing of alteration

→ must have minimal air leakage

Operating at reduced temperatures will minimize burner maintenance. Boiler performance will be affected, however, by the increased cooling air flow. requirements IPSC provided the following cost evaluation information that was used for the economic analysis.

cost of money 8.6%

Cost Evaluation Information

Unit Life (for each)	35 years
Capacity Rating (each unit)	800 MW net
Net Unit Heat Rate	9600 Btu/Kwhr
Capacity Factor	83 %
Equivalent Availability	89 %
Forced Outage Rate	2 %
Load Factor (gross)	95 %
Fuel Costs	1.45 $/MBtu
Boiler Efficiency	89.4 %
Change in out of service Burner Temp. versus change in Boiler Efficiency	100°F/1/2%

WOULD LIKE TO SEE PERF CALCS
— EXIT LOSSES
— FAN POWER
ETC
TO GET THE 1/2%

(1% controlling factor 850 down from 1150 (typical 200 diff) No nozzle modification)

The boiler efficiency would decrease by 1% when the out of service burners are maintained at 1150°F instead of 1350°F. The calculations for increased fuel costs in order to maintain current operation are shown below.

800 MW net x 83% Capacity Factor = 664 MW

664 MW x 9600 Btu/Kwhr = 6,374.4 MBtu/hr

6,374.4 MBtu/hr x 1.45 $/MBtu = 9242 $/hr

Fuel Costs @ 89.4% Boiler Eff. = 80,967,628 $/yr

$$\text{Heat to Steam} = \text{Eff}_1 \times \text{Heat Input}_1 = \text{Eff}_2 \times \text{Heat Input}_2$$

$$(9600\ \text{Btu/Kwhr}) \times (89.4\%) = (X) \times (88.4\%)$$

$$X = 9708.6\ \text{Btu/Kwhr}$$

664 MW x 9708.6 Btu/Kwhr = 6,446.5 MBtu/hr

6,446.5 MBtu/hr x 1.45 $/MBtu = 9347 $/hr

Fuel Costs @ 88.4% Boiler Eff. = 81,883,552 $/yr

Increased Fuel Costs per Boiler = 915,923 $/yr

The following cost summary is based on a quantity of 48 burners for one unit.

Cost Summary

Material Cost (does not include OEM markup)	$292,800
Engineering	20,000
Freight	12,000
Installation Labor & Equipment	432,000
Total (20-30 year life)	$756,000

NEED TOTAL P.V. FOR OPTION INCLUDING FUEL COST

6.4 Redesign Burner

Installing burners that have been redesigned to operate at 1350°F when out of service is the fourth alternative. The advantages of this alternative are that the boiler efficiency will not be affected and the estimated burner life would be 20-30 years. The burner would remain adjustable which would allow the cooling air flow to be balanced to each of the out of service burners. The new burner should incorporate the following design changes:

Need: proposed drawing markup

HD style modification ~~design~~ one piece installation

1. The stainless steel material and plate thickness should change on several of the burner components that have failed. This is evidenced by the current HD registers that have been installed in the upper row of burners and have already been permanently warped. A higher grade of stainless steel such as AISI 309 or 310 with a low carbon content would be better suited for high temperatures and welded constructions than a 304 material. This material would provide a higher creep strength and also alleviate long term effects of weld decay (Appendix C). Material thickness would ~~probably~~ also

IP7_004372

need to be increased on current 309 components to overcome the high stresses that are occurring.

2. The outer register should use the HD register linkage design. This will increase the ability of the register to remain adjustable. Placing the outer register farther back from the furnace should also be considered. This would reduce the amount of heat transfer by radiation and assist in lowering the temperatures of the register back plate and doors. The disadvantage could be the reduction of swirl that is imparted to the secondary air. But considering that the existing burners have good stability while operating with low pressure drop across the burner and severely trimmed register doors, it is questionable whether or not a high degree of swirl is required.
3. The slip seal casing should be redesigned to allow for the large thermal expansions.
4. The reinforcing bars that are welded to the outside of the inner air sleeve should be SST 304 instead of carbon steel.
5. Extension of the alloy tip on the coal nozzle may be necessary because the thermocouple located at the carbon steel junction should be limited to 850°F.
6. Register control drives should be considered. ~~but are not required.~~ The drives would allow adjustment of out of service burners (to balance cooling air) from the control room.

All SS. coal nozzle ?/!

INDIVIDUAL BURNER ΔP?

The following cost summary is based on a quantity of 48 burners for one unit.

Cost Summary

Material Cost (does not include OEM markup)	$360,000
Engineering	40,000
Freight	12,000
Installation Labor and Equipment	432,000
Total Cost (20-30 year life)	$844,000

seems awfully low in comparison to ~~other~~ alternative ($100 difference for redesigned burner?)
$7500 per burner?
low

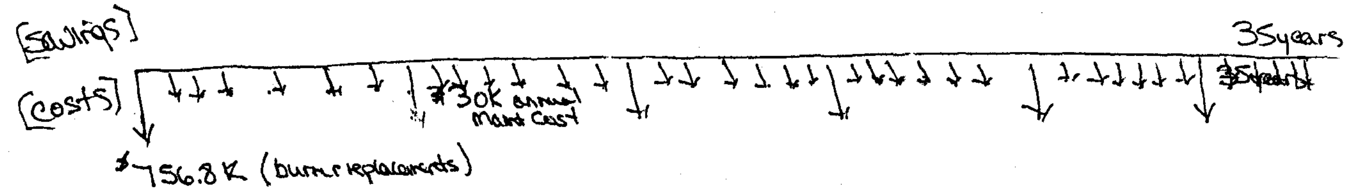
IP7_004373

BURNER ALTERNATIVES - Summary

evaluate present values for each alternative
35year unit life / burner life 20-30 years 5-7 replacement
calculate for both 1 unit / 2 units

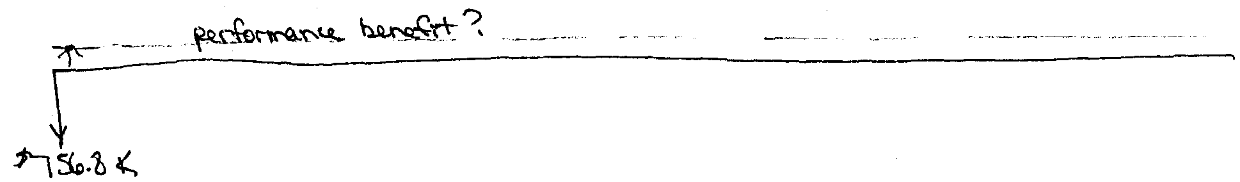
Alternative 1
Current mode of operation

PV = 1 unit ? loss
2 units ?



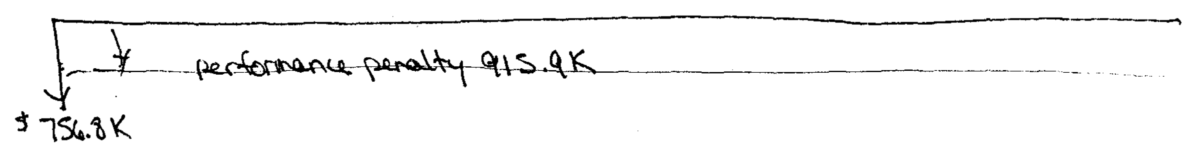
Alternative 2
8 pulverizer mode of operation

PV = 1 unit ?
2 units ?



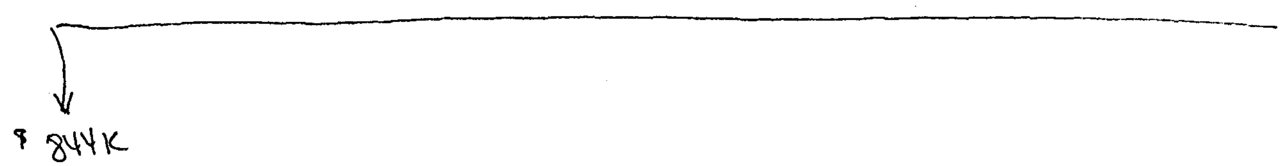
Alternative 3
Increase cooling air requirement

PV = 1 unit ?
2 units ?



Alternative 4
Redesigned Burners

PV = 1 unit ?
2 units ?



7.0 RECOMMENDATIONS & CONCLUSIONS

7.1 Recommended Alternative

McCurdy

The best alternative to ~~solve~~ resolve the burner problems that are being experienced at IGS Units 1 & 2 is Alternative #4 to replace the register assemblies with one piece HB style redesign, throat sleeves, and throat sleeve casings and SS coal nozzle with a new design that will operate at 1350°F. Boiler efficiency will not be affected and estimated burner life should be 20-30 years. The current condition of the existing burners warrant this change because they have a short life expectancy.

→ Discuss Alter 2 maybe impractical due to present maint setup

7.2 Interim Solution

If ~~it is determined that installation will not occur within the next six months,~~ it is recommended that cooling air flow be increased to limit the burner temperatures to 1150°F. to prevent additional damage This will reduce the chance of a safety risk and possible forced outage due to major burner failure.

Also recommended to run all eight pulverizers whenever they are available for service.

FORCED OUTAGE DOESN'T SEEM REALISTIC TO ME

7.3 Instrumentation & Controls

Additional instrumentation and controls is not required at this time if cold air tests are performed on the new burners to determine cooling air settings. While two 2 thermocouples on each burner are not enough to assure balanced cooling air flow, they are adequate to alarm the control room of any high temperature excursions so that total cooling air flow can be increased.

Is this practical in comparison of on-line operation and problems keeping unit tuned.

Though this may not be practical in comparison to on-line operation and optimizing combustion air flow required combustion tuning requirements of optimizing combustion air flow settings through the burner (O_2/CO/NOx/LOI tuning), the recommendation of a two register automatic setting for on-line and off-line operation is imperative to balancing air flow for both conditions.

If Alternative 1, 2 or 3 is chosen

Construction Schedule

Add estimated time of replacement/repairs (Keep in mind sectionalized Maint. Overhauls at 16 burner total [8 front-8 rear] per major outage (1st year - 3rd level 4 weeks). Schedule 1 burner row replacement per major outage (1st year - 3rd level (worst [since no HO's]) 2nd year - 4th level 3rd year - 2nd level. 4th year - 1st level.

Unit 1 Spring / Unit 2 Fall of each year

☆ Need proposed drawings of revised burner design

Appendix C

Weld Decay of 18% Cr, 8% Ni in Stainless Steel

Type 304 stainless steel contains 18% Ni, and 0.08% C maximum. It is usually delivered in the single-phase austenitic structure obtained by rapid cooling from elevated temperatures. The $M_{23}C_6$* phase can precipitate, however, if the steel is reheated in the two-phase field. During welding, the weld zone is heated to the liquid state and cools rapidly enough to avoid carbide precipitation. However, there is a region adjacent to the weld that has been heated just enough to precipitate $M_{23}C_6$. This usually takes place at grain boundaries. Because of the high chromium content of the carbide, the nearby regions are impoverished of chromium as the carbide is formed. The chromium level falls below 10% in these regions near a grain boundary. Hence the low-chromium regions are not passive(<10-13% Cr), whereas the remainder of the matrix is passive. The result is galvanic action between the grain boundary region and the higher-chromium regions within the grain. It should be emphasized that it is not the $M_{23}C_6$ particles that are corroded, but the low-chromium-iron matrix. The $M_{23}C_6$ particles can be recovered after corrosion. Under the electron microscope, they appear as platelike crystals. This type of corrosion can be avoided by using a solution heat treatment at 2000°F (1093°C) after welding.

This type of grain boundary corrosion can also be minimized by using 18% Cr, 8% Ni steel to which a stronger carbide-former than chromium (for example, titanium or niobium) is added or by specifying a very low-carbon level.

*$M_{23}C_6$ is an iron-chromium carbide that can contain up to 30 wt % iron. With 30 wt % Fe, the omium content is in excess is in excess of 60 wt % for the indicated stoichiometry.

~~not referenced~~

? pertinent p20

[1]Flinn, R.A. and Trojan, P.K., Engineering Materials and Their Applic
p. 530, Third Edition.

Photos
Headings
quad to sheet

Date: ____________
Insp: ____________

Burner # D1

	Condition				Warpage			Comments
	Gd	Ok	Pr	rr	No	Yes	Severe	
Casing				X			X	
Packing				X				
Register		X						~~Linkage~~
Front PL		X						
Rear PL		X						
Doors				X				
Shaft		X						
Linkage								disconnected
Spin Vane		X						
Bell Crank		X						
Linkage		X						
Sleeve		X						
Sliding Slv.			X					overheating & stiff
Back PL		X						

These sheets need to be typed up (readable)
Make separate attachment
Summary of major problems sheet